UM0252
User manual

SEMITOP 3 Power Board

Introduction

The SEMITOP 3 Power Board (STEVAL-IHM009V1) is designed to evaluate the advantages of using a 3-Phase Inverter with an ST Power module for motor control. It can be driven by a control board via six in-line connectors. This demo board can work directly from a DC power supply. The auxiliary power supply is located on the Power Board and works with applications rated above $50V_{DC}$.

Some of the many advantages include:

- Quick to install and easy to run.
- Re-usable design (the Gerber files are available for free).
- The original partition design between the Power Board and the control board provides very effective system noise immunity.

Note: Please read Section 2: Safety and operating instructions on page 5 before attempting any operations using the SEMITOP 3 Power Board.

The SEMITOP 3 3-Phase Inverter Board enables you to evaluate a three-phase power inverter using ST's dedicated chip set. When connected to a motor, the Power Board demonstrates possible configurations for smooth, silent, and efficient motor operation. The design boards are well-suited for several kinds of applications which require 6-step commutation or 6-signal PWM (sine wave-modulated) output, including:

- 3-Phase AC Induction motor control
- 3-Phase PMDC/AC or BLDC/AC (Trapezoidal driven) motor control
- 3-Phase PMAC or BLAC (sinusoidal driven) motor control
- Single- and 3-phase UPS (Uninterruptable Power Supply)

This evaluation board offers customization options as well, making it an excellent choice as an original platform for a more complete and dedicated system. Special care has been taken during the layout process to provide a very low level of interference between the power and the signal noise. This makes the system quite solid under almost all operating conditions.

This evaluation kit consists of two (2) boards:

1. SEMITOP 3 3-Phase Inverter main evaluation board (3000W nominal rated power)
2. ControlBD-7FMC2 control board

Warning: The high voltage levels used to operate the motor drive can present a serious electrical shock hazard. This kit must be used only in a power laboratory only by engineers and technicians who are experienced in power electronics technology.

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1 General information

This document provides instructions on setting up and using the following SEMITOP 3 Power Board evaluation configurations for various types of applications:

- 3-phase AC induction motor control software
- 3-phase PMDC/AC or BLDC/AC (trapezoidal driven) motor control software
- 3-phase PMAC or BLAC (sinusoidal driven) motor control software

1.1 Terms and abbreviations

Table 1 lists common abbreviations used in this document.

Table 1. List of abbreviations

Abbreviation	Description
BLAC	Brushless AC
BLDC	Brushless DC
CCW	Counter Clockwise
CW	Clockwise
GUI	Graphical User Interface
PMAC	Permanent Magnet AC
PMDC	Permanent Magnet DC

1.2 Related documentation

UM0121: ControlBD-7FMC2 Reference Design Graphical User Interface (GUI)

UM0122: Motor Drive Reference Design Manual

2 Safety and operating instructions

During assembly and operation, the SEMITOP 3 Power Board poses several inherent hazards, including bare wires, moving or rotating parts, and hot surfaces. There is danger of serious personal injury and damage to property, if the Kit or its components are improperly used or installed incorrectly.

All operations involving transportation, installation and use, as well as maintenance are to be carried out by skilled technical personnel (national accident prevention rules must be observed).

For the purpose of these basic safety instructions, “skilled technical personnel” are suitably qualified people who are familiar with the installation, use, and maintenance of power electronic systems.

2.1 SEMITOP 3 Power Board intended use

The SEMITOP 3 Power Board is a component designed for demonstration purposes only, and shall not be used for electrical installation or machinery. The technical data as well as information concerning the power supply conditions shall be taken from the documentation and strictly observed.

2.2 SEMITOP 3 Power Board installation

The installation and cooling of the SEMITOP 3 Power Board must comply with the specifications and the targeted application. For more information, refer to *Chapter 4: Getting started on page 8*.

- The motor drive converters shall be protected against excessive strain. In particular, no components are to be bent, or isolating distances altered, during the course of transportation or handling.
- No contact shall be made with electronic components and contacts.
- The boards contain electrostatically sensitive components that are prone to damage through improper use. Electrical components must not be mechanically damaged or destroyed (to avoid potential health risks).

2.3 Electronic connections

Applicable national accident prevention rules must be followed when working on the main power supply with a motor drive.

The electrical installation shall be completed in accordance with the appropriate requirements (e.g., cross-sectional areas of conductors, fusing, PE connections). For more information, refer to *Chapter 4: Getting started on page 8*.

2.4 SEMITOP 3 Power Board operation

A system architecture which supplies power to the SEMITOP 3 Power Board shall be equipped with additional control and protective devices in accordance with the applicable

safety requirements (e.g., compliance with technical equipment and accident prevention rules).

Note: Do not touch the Design Boards after disconnection from the voltage supply, as several parts and power terminals which contain possibly energized capacitors need to be allowed to discharge.

3 Electrical characteristics

Table 2 summarizes the electrical characteristics of the SEMITOP 3 Power Board.

Table 2. Voltage ratings

Power Board parameters	Values	
	Min.	Max.
DC input voltage range with on-board auxiliary supply	70V	370V
External auxiliary supply source	14V	18V

Note: For a complete list of Control Board features and programming information, please refer to user manuals UM0121 and UM0122.

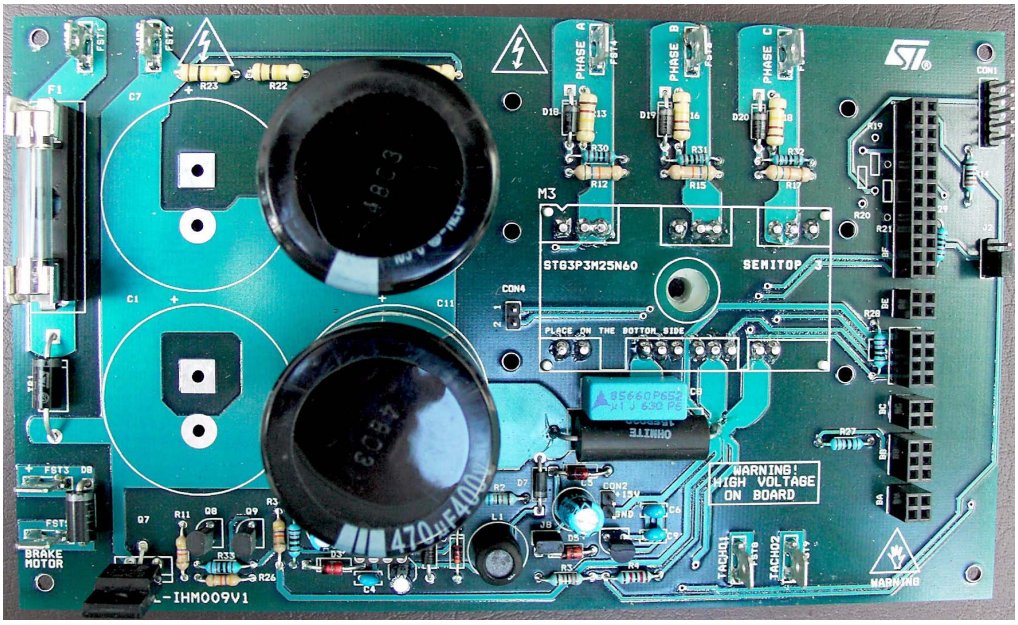
4 Getting started

This user manual covers most system features, starting with the front-end main power supply to the power stages, including the operation of the +5V/+15V power supply and microcontroller.

This kit includes the following key components:

- Motor control-dedicated microcontrollers
- L6386 half-bridge drivers
- 600V Insulated Gate Bipolar Transistor (IGBT) SEMITOP 3 module
- VIPer12 auxiliary supply smart power switch
- Small-Signal Bipolar Transistors
- STTH108 and BAS70W Diodes
- 78L05 voltage regulator
- M95040 EEPROM memory
- P6KE400A and 1.5KE400A Transil™ diodes (optional)

Figure 1. SEMITOP 3 Power Board (STEVAL-IHM009V1)



4.1 Environmental safety considerations

The Power Boards must only be used in a power laboratory. The high voltage used in any AC drive system presents a serious shock hazard. A complete laboratory setup consists of an isolated AC power supply, the SEMITOP 3 Power Board, an AC Induction motor, and isolated (laboratory) power supplies for +15V (as needed).

The SEMITOP 3 Power Boards are not electrically isolated from the AC input. This topology is very common in AC drives. The microprocessor is grounded by the integrated Ground of the DC bus. The microprocessor and associated circuitry are hot and MUST be isolated from user controls and serial interfaces.

Note: Any measurement equipment must be isolated from the main power supply before powering up the motor drive. To use an oscilloscope with the demos, it is safer to isolate the AC supply AND the oscilloscope. This prevents a shock occurring as a result of touching any SINGLE point in the circuit, but does NOT prevent shocks when touching TWO or MORE points in the circuit.

An isolated AC power supply can be constructed using an isolation transformer and a variable transformer. A schematic of this AC power supply is in the Application Note, “AN438, TRIAC + Microcontroller: Safety Precautions for Development Tools.” (Although this Application Note was written for TRIAC, the isolation constraints still apply for fast switching semiconductor devices such as IGBTs.)

Warning: SEMITOP 3 Power Boards have no isolation shield or any other type of protection case. The demonstration board must be handled very carefully, as high potential (energy) parts are open and can be touched. The user MUST avoid connecting or removing cables during operation of an electric motor, or touching any part of the system when it is connected to the main power supply.

Caution: Isolating the application rather than the oscilloscope is highly recommended in all cases.

After turning the motor off, the DC-link capacitor may still hold voltage for several minutes (refer to the LEDs on the control board).

Do NOT expose the evaluation kits to ambient temperatures of over 35°C, as this may harm the components or reduce their lifetimes.

For more information on the evaluation software and libraries, refer to Application Notes AN1291, AN1083, and AN1276.

4.2 SEMITOP 3 Power Board connections

Caution: Before supplying power to the boards, verify the connection integrity and make sure there are no unintended earth/ground loops caused by peripheral (e.g., test) equipment (e.g., PC or oscilloscope).

Cables

Choose the appropriate gauge wiring for the motor's current ratings.

Be sure that a jumper is placed between pins 1 and 2 of Jumper J2.

Note: Electrostatic charges may accumulate on a floating motor and increased voltage may be present due to energized capacitors which need to be allowed to discharge.

Note: Input voltage must be kept below 130 V_{DC}. If this value is exceeded for any reason, the bulk capacitors will be protected by the optional Transil™ diode TR1 (P6KE400A D0-15 or 1.5KE400A D0-201) and clamp to the high voltage DC bus.

4.3 Downloading the firmware into the ST7FMC Microcontroller

For configuring the ControlBD-7FMC2 for each evaluation application, it is necessary to download the proper binary source code into the microcontroller.

Open loop applications

For "Open Loop" applications, the binary file provided with AC software library can be downloaded into the ST7FMC code memory as it is. This can be done with the Datablaze Programmer utility. Please refer to User Manual UM0121, "ControlBD-7FMC2 Reference Design Graphical User Interface (GUI)" for details.

Closed loop applications

Unlike "Open Loop" applications, when using a "Closed Loop" application, a new ".S19" binary file must be generated using the RDK-GUI PC software tool provided with the companion CD-ROM.

Viewing parameter settings

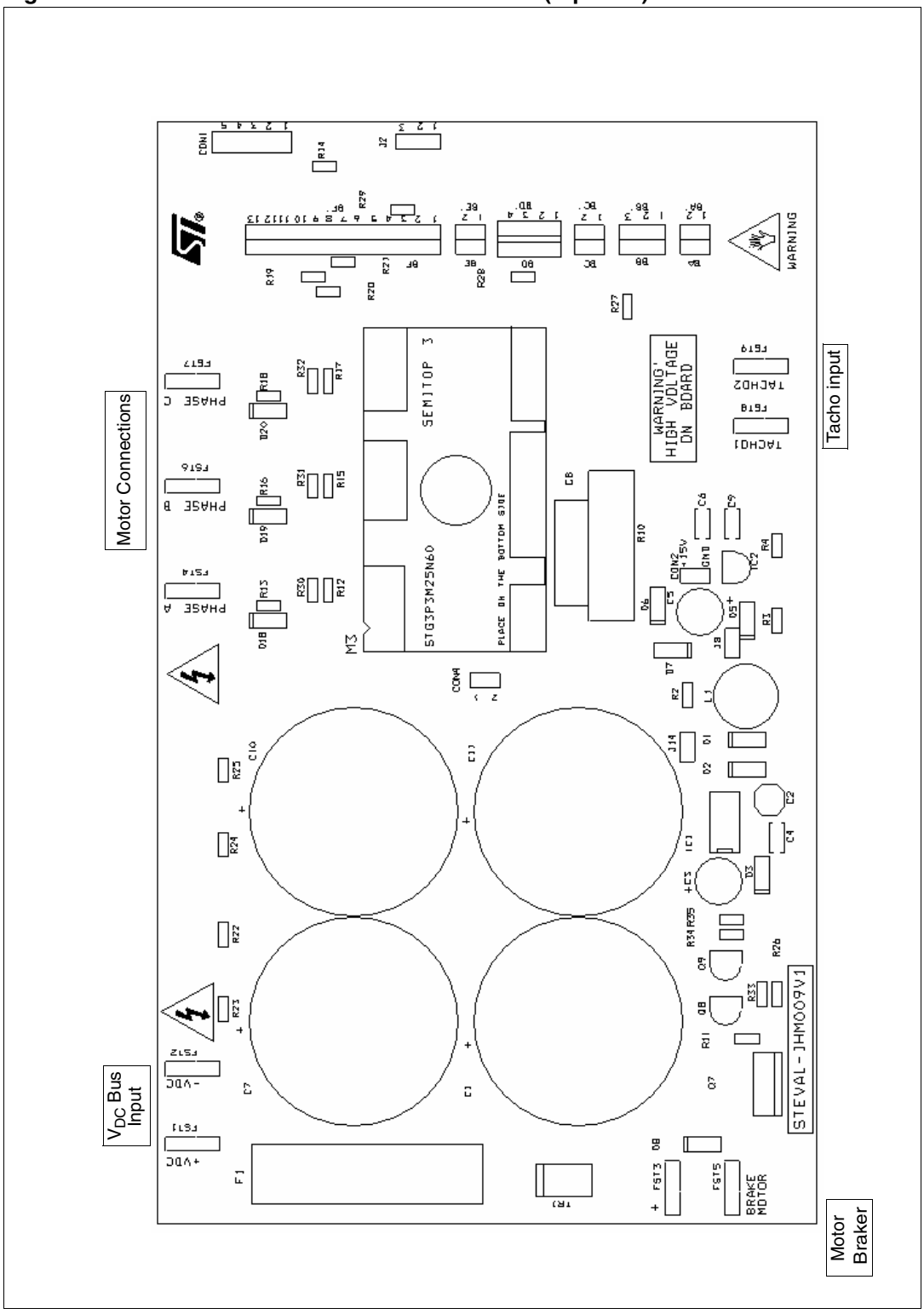
The settings provided for this binary code can be viewed in the main (basic parameters) window of the Reference Design RDK-GUI tool after selecting the corresponding motor option.

4.4 Mandatory checks before operation

You must perform the following verifications before switching ON the evaluation board:

- Ensure that the jumpers are correctly configured.
- The motor is correctly connected and grounded.
- A control board with validated software is plugged into the Power Board
- There are no metal parts on, below, or around the PC boards.
- There are no unintended earth/ground loops caused by peripheral devices (e.g., test) or equipment (e.g., PC or oscilloscope).
- The motor and mechanical load are safely housed so that rotating parts cannot be inadvertently accessed and cause injury (e.g., loose clothing, long hair).

Figure 2. SEMITOP 3 Power Board connections (top view)



5 3-phase AC induction motor control software (open loop)

The software operates the ControlBD-7FMC2 board in Standalone mode. Push-button switch S2 controls the ON/OFF function and the on-board trimmer potentiometers P2 and P3 respectively set the voltage and frequency levels.

5.1 Start-up procedure

1. Download the firmware into the ST7FMC memory as described in *Section 4.3: Downloading the firmware into the ST7FMC Microcontroller*.
2. Connect a 3-phase induction motor (mechanically unloaded) to connectors FST4, FST6, and FST7. Sequencing is arbitrary and the direction of rotation will be set later.
3. Remove the control board jumpers J11 and J12, and set jumper J10 between points 1 and 2.
4. Set potentiometers P2 and P3 to full Counter Clockwise (CCW) position. Potentiometer P3 is the Frequency setting. Full CCW to full Clockwise (CW) corresponds to a range of 10Hz to 340Hz, with increments of 1Hz.
5. Monitor one of the three motor currents using an isolated current probe.
6. Apply the DC voltage supply to connectors FST1 (+) and FST2 (-).

Note: In the Idle state, a green LED will be flashing, and then it will stay on.

7. Set potentiometer P3 to approximately 60Hz (1/4 turn CW).
8. Set Switch S2 to ON.

Note: In the Run state, the red LED will light up. The motor current should remain at zero, although some switching noise may be observed.

9. Slowly rotate potentiometer P2 CW to begin increasing the Voltage setting from zero. You should start to see a 60Hz (approximately) current build-up in the motor and then the motor should begin to rotate.
10. Continue to increase the setting until the motor reaches the expected speed for this excitation frequency. Keep in mind that some slip will be expected. The current waveform should remain fairly sinusoidal. If the waveform becomes highly distorted or exceeds the motor rating, decrease the Voltage setting (potentiometer P2).

Warning: The entire circuit board and motor output terminals are always “hot” with respect to earth ground, even when the drive is in a stopped condition.

5.2 Commands

Push switch S2 to start the motor. When the drive is running, push again switch S2 to stop the motor.

The controller always enforces a maximum slew limit on changes to the frequency of excitation applied to the motor. In practice this softens the motion of the motor, causing it to ramp up to the commanded frequency (speed) when going from STOP to RUN. Decreasing the frequency and voltage applied to the motor slowly decreases the speed (to zero).

Note: It is acceptable to start or stop the drive at any time and speed because of the slew limit.

5.3 Motor direction

If you wish to change the running direction of the motor, simply disconnect the drive from the main voltage supply, wait for the bulk capacitors to discharge, then swap any two of the three motor wires.

5.4 Potentiometer commands

- P2 sets the voltage applied from the minimum value (0) to the maximum VBUS. This setting is internally limited with a V/F curve (refer to User Manual UM0121).
- P3 sets the motor frequency and thus the motor speed. Use P3 to set the stator frequency as well. The contribution of P3 is 10Hz when it is in the maximum CCW position and will increment downward by 1Hz resolution to reach 340Hz by rotating the potentiometer to full CW position.

Note: For configuration of the software library with the RDK-GUI, see User Manual UM0121.

6 3-phase AC induction motor control software (closed loop)

The software operates the ControlBD-7FMC2 board in a Standalone mode. Push-button switch S2 controls the ON/OFF function and the on-board trimmer potentiometer (P3) sets the target rotor frequency from 10 to 340 Hz (for one pole pair motor).

6.1 Start-up procedure

1. Download the firmware into the ST7FMC memory as described in *Section 4.3: Downloading the firmware into the ST7FMC Microcontroller*.
2. Connect a 3-phase induction motor (mechanically unloaded) to connectors FST4, FST6, and FST7. Sequencing is arbitrary and the direction of rotation will be set later.
3. Remove the control board jumpers J11 and J12, and set jumper J10 between points 1 and 2.
4. Connect the two tachogenerator terminals into connectors FST8 and FST9.
5. Set the potentiometer (P3) to full CCW position. Full CCW to full CW corresponds to a target rotor frequency range between 10 Hz and 340 Hz (for one pole pairs motor) in increments of 1Hz.
6. Monitor one of the three motor currents using an isolated current probe.
7. Apply the DC voltage supply to connectors FST1 (+) and FST2 (-).

Note: In the Idle state, a green LED will be flashing, and then it will stay on.

8. Set potentiometer P3 to approximately 60 Hz (1/4 turn CW).
9. Set Switch S2 to ON.

Note: In the Run state, the red LED will light up. The motor current should remain at zero, although some switching noise may be observed. The motor should reach the target rotor frequency set by potentiometer P3. The current waveform should remain fairly sinusoidal. If the waveform becomes highly distorted or exceeds the motor rating, modify the V/ F curve (refer to User Manual UM0121).

Warning: The entire circuit board and motor output terminals are always “hot” with respect to earth ground, even when the drive is in a stopped condition.

6.2 Commands

Push switch S2 to start the motor. When the drive is running, push again switch S2 to stop the motor.

The controller always enforces a maximum slew limit on changes to the frequency of excitation applied to the motor. In practice this softens the motion of the motor, causing it to ramp up to the commanded frequency (speed) when going from STOP to RUN. Decreasing the frequency and voltage applied to the motor slowly decreases the speed (to zero).

Note: It is acceptable to start or stop the drive at any time and speed because of the slew limit.

6.3 Motor direction

If you wish to change the running direction of the motor, simply disconnect the drive from the main voltage supply, wait for the bulk capacitors to discharge, then swap any two of the three motor wires.

6.4 Potentiometer commands

P3 sets the rotor target frequency and thus the motor speed. The contribution of P3 is 10Hz when it is in the maximum CCW position and will increment downward by 1Hz resolution to reach 340Hz (for one pole pair motor) by rotating the potentiometer to full CW position.

Note: For configuration of the software library with the RDK-GUI, see User Manual UM0121.

7 3-phase PMDC/AC or BLDC/AC (trapezoidal driven) motor control software (open loop)

The software operates the ControlBD-7FMC2 board in Standalone mode. Push-button switch S2 controls the ON/OFF function and the on-board trimmer potentiometer (P1) sets the motor speed to a PWM duty cycle between 0% and 97%.

7.1 Start-up procedure

1. Download the firmware into the ST7FMC memory as described in *Section 4.3: Downloading the firmware into the ST7FMC Microcontroller*.
2. Connect a 3-phase BLDC motor (mechanically unloaded) to connectors FST4, FST6, and FST7. Sequencing is arbitrary and the direction of rotation will be set later.
3. Set the control board jumper J10 between points 2 and 3, and jumpers J11 and J12 between points 1 and 2.
4. Set the potentiometer (P1) to a predetermined position (e.g., center).
5. Apply the DC voltage supply to connectors FST1 (+) and FST2 (-).

Note: In the Idle state, the green LED will light up.

6. Set Switch S2 to ON.

Note: In the Run state, the red LED will stay on.

The motor will be pulled into alignment position first, then it will start to turn. If the motor starts successfully, adjust potentiometer P1 to change the motor speed.

7.2 Commands

Push switch S2 to start the motor. When the drive is running, push again switch S2 to stop the motor.

Potentiometer P1 sets the motor speed command. Since this is a voltage mode open loop control, it sets the PWM duty cycle from 0% to 97%. In order to detect the back EMF, the motor must first be started and brought up to a certain speed where the back EMF voltage (BEMF) can be detected. Before the motor is started, the controller will bring the rotor to a predetermined position. This is called the “alignment phase”. After the rotor is in the alignment position, a fixed accelerating commutation command will be invoked by the microcontroller. If the acceleration rate is correct, the motor will be accelerated until the microcontroller can detect the BEMF and switch to Auto-switched mode.

7.3 Motor direction

If you wish to change the running direction of the motor, simply disconnect the drive from the main voltage supply, wait for the bulk capacitors to discharge, then swap any two of the three motor wires.

Note: For configuration of the software library with the RDK-GUI, see User Manual UM0121.

8 3-phase PMDC/AC or BLDC/AC (trapezoidal driven) motor control software (closed loop)

The software operates the ControlBD-7FMC2 board in Standalone mode. Push-button switch S2 controls the ON/OFF function and the on-board trimmer potentiometer (P1) sets the motor speed to a PWM duty cycle between 0% and 97%.

8.1 Start-up procedure

1. Download the firmware into the ST7FMC memory as described in *Section 4.3: Downloading the firmware into the ST7FMC Microcontroller*.
2. Connect a 3-phase induction motor (mechanically unloaded) to connectors FST4, FST6, and FST7. Sequencing is arbitrary and the direction of rotation will be set later.
3. Set the control board jumper J10 between points 2 and 3 and jumpers J11 and J12 between points 1 and 2.
4. Set the potentiometer (P1) to a predetermined position (e.g., center).
5. Monitor one of the three motor currents using an isolated current probe.
6. Apply the DC voltage supply to connectors FST1 (+) and FST2 (-).

Note: In the Idle state, the green LED will light up.

7. Set Switch S2 to ON.

Note: In the Run state, the red LED will stay on.

The motor will be pulled into alignment position first, then it will start to turn. If the motor starts successfully, adjust P1 to change the motor speed.

8.2 Commands

Push switch S2 to start the motor. When the drive is running, push again switch S2 to stop the motor.

Potentiometer P1 sets the motor target frequency speed command, and sets the rotor frequency between 50Hz and 200Hz (for two pole pairs motor). In order to detect the back EMF, the motor must first be started and brought up to a certain speed where the back EMF voltage (BEMF) can be detected. Before the motor is started, the controller will bring the rotor to a predetermined position. This is called the “alignment phase”. After the rotor is in the alignment position, a fixed accelerating commutation command will be invoked by the microcontroller. If the acceleration rate is correct, the motor will be accelerated until the microcontroller can detect the BEMF and switch to auto-switched mode.

8.3 Motor direction

If you wish to change the running direction of the motor, simply disconnect the drive from the main voltage supply, wait for the bulk capacitors to discharge, then swap any two of the three motor wires.

Note: For configuration of the software library with the RDK-GUI, see User Manual UM0121.

9 3-phase PMAC or BLAC (sinusoidal driven) motor control software (open loop)

The software operates the ControlBD-7FMC2 board in Standalone mode. Push-button switch S2 controls the ON/OFF function and the on-board trimmer potentiometer P1 sets the voltage level index and potentiometer P3 can set the Phase Shift angle.

9.1 Hardware modifications

To use the SEMITOP 3 Power Board to drive a PMAC sensor motor, the user must remove resistors R30, R12, R31, R15, R32 and R17 and mount the resistors (4.7kΩ) R19, R20, and R21.

Note: In each of these cases, capacitors (10nF) C22, C23, and C24 capacitors must be mounted on the ControlBD-7FMC2 board.

9.2 Start-up procedure

1. Download the firmware into the ST7FMC memory as described in *Section 4.3: Downloading the firmware into the ST7FMC Microcontroller*.
2. Connect a 3-phase PMAC motor (mechanically unloaded) to connectors FST4, FST6, and FST7. Sequencing is arbitrary and the direction of rotation will be set later.
3. Connect at least 1 Hall sensor signal to pin1 of the CON1 connector of the SEMITOP 3 Power Board.

Note: The CON1 connector has the following pin connections:

- Pin 1: Hall sensor signal 1
- Pin 2: Hall sensor signal 2
- Pin 3: Hall sensor signal 3
- Pin 4: +5 Volt
- Pin 5: GND

4. Connect the control board jumpers J11 and J12, and set jumper J10 between points 2 and 3.
5. Set potentiometer P1 to between full CW position and full CCW position and potentiometer P3 to full CCW position.
6. Monitor one of the three motor currents using an isolated current probe.
7. Apply the DC voltage supply to connectors FST1 (+) and FST2 (-).

Note: In the Idle state, the green LED will stay on.

8. Set Switch S2 to ON.

Note: In the Run state, the red LED will light up.

The motor may run poorly (e.g., discontinuous mode or oscillation) until the correct Phase Shift is set by potentiometer P3.

9. Slowly rotate potentiometer P3 CW to find the correct Phase Shift. The correct value is reached when the user notices the motor running well (without discontinuity).

Note: Make final adjustments to the Phase Shift by monitoring the current on the oscilloscope. The optimal Phase Shift normally minimizes the motor current amplitudes (see the Application Note AN1947 for more information).

10. Rotate potentiometer P1 in the CW direction until the motor has come up to the expected speed for this excitation level.

Note: The current waveforms should remain fairly sinusoidal.

Warning: The entire circuit board and motor output terminals are always "hot" with respect to earth ground, even when the drive is in a stopped condition.

9.3 Commands

Push switch S2 to start the motor. When the drive is running, push again switch S2 to stop the motor.

The controller always enforces a maximum slew limit on changes to the frequency of excitation applied to the motor. In practice this softens the motion of the motor, causing it to ramp up to the commanded frequency (speed) when going from STOP to RUN. Decreasing the frequency and voltage applied to the motor slowly decreases the speed (to zero).

Note: It is acceptable to start or stop the drive at any time and speed because of the slew limit.

9.4 Motor direction

If you wish to change the running direction of the motor, simply disconnect the drive from the main voltage supply, wait for the bulk capacitors to discharge, swap any two of the three motor wires, and execute the start-up procedure, beginning at Step 10.

9.5 Potentiometer commands

Potentiometer P1 sets the Voltage applied from the minimum value (0) to the maximum VBUS. This setting is internally limited with a V/F curve (refer to User Manual UM0121).

Potentiometer P3 sets the Phase Shift (if this feature is selected by the user).

Note: For configuration with the RDK-GUI, see User Manual UM0121.

10 3-phase PMAC or BLAC (sinusoidal driven) motor control software (closed loop)

The software operates the ControlBD-7FMC2 board in Standalone mode. Push-button switch S2 controls the ON/OFF function and the on-board trimmer potentiometer P1 sets the target rotor speed from the minimum (maximum CCW position) to maximum speed (maximum CW position). Potentiometer P2 is disabled by default or sets the integral coefficient of the PI controller if this feature is selected by the user, and potentiometer P3 sets the Phase Shift (by default) or the proportional coefficient of the PI controller if this feature is selected.

The user can set either the Phase Shift by using P3 or the PI parameter by using potentiometers P2 and P3. It is impossible to select both features simultaneously (this feature must be selected with the RDK-GUI, see User Manual UM0121).

10.1 Hardware modifications

To use the SEMITOP 3 Power Board to drive a PMAC sensor motor, the user must remove resistors R30, R12, R31, R15, R32 and R17 and mount resistors (4.7kΩ) R19, R20 and R21.

Note: In each of these cases, capacitors (10nF) C22, C23, and C24 capacitors must be mounted on the ControlBD-7FMC2 board.

10.2 Start-up procedure

1. Download the firmware into the ST7FMC memory as described in *Section 4.3: Downloading the firmware into the ST7FMC Microcontroller*.
2. Connect a 3-phase PMAC motor (mechanically unloaded) to connectors FST4, FST6, and FST7. Sequencing is arbitrary and the direction of rotation will be set later.
3. Connect at least 1 Hall sensor signal into pin 1 of the CON1 connector of SEMITOP 3 Power Board

Note: The CON1 connector has the following pin connections:

- Pin 1: Hall sensor signal 1
- Pin 2: Hall sensor signal 2
- Pin 3: Hall sensor signal 3
- Pin 4: +5 Volt
- Pin 5: GND

4. Connect the control board jumpers J11 and J12, and set jumper J10 between points 2 and 3.
5. Set potentiometer P1 to between full CW position and full CCW position and potentiometer P3 to full CCW position.
6. Monitor one of the three motor currents using an isolated current probe.
7. Apply the DC voltage supply to connectors FST1 (+) and FST2 (-).

Note: In the Idle state, the green LED will stay on.

8. Set Switch S2 to ON.

Note: In the Run state, the red LED will light up.

The motor may run poorly (e.g., discontinuous mode or oscillation) until the correct Phase Shift is set by P3.

9. Slowly rotate potentiometer P3 CW to find the correct Phase Shift. The correct value is reached when the user notices the motor running well (without discontinuity).

Note: Make final adjustments to the Phase Shift by monitoring the current on the oscilloscope. The optimal Phase Shift normally minimizes the motor current amplitudes (see the Application Note AN1947 for more information).

10. Set potentiometer P1 to the middle, between the maximum CCW and maximum CW position, and push switch S2.
11. Rotate potentiometer P1 until the motor has come up to the expected speed for this excitation level.

Warning: The entire circuit board and motor output terminals are always "hot" with respect to earth ground, even when the drive is in a stopped condition.

10.3 Commands

Push switch S2 to start the motor. When the drive is running, push again switch S2 to stop the motor.

The controller always enforces a maximum slew limit on changes to the frequency of excitation applied to the motor. In practice this softens the motion of the motor, causing it to ramp up to the commanded frequency (speed) when going from STOP to RUN. Decreasing the frequency and voltage applied to the motor slowly decreases the speed (to zero).

Note: It is acceptable to start or stop the drive at any time and speed because of the slew limit.

10.4 Motor direction

If you wish to change the running direction of the motor, simply disconnect the drive from the main voltage supply, wait for the bulk capacitors to discharge, swap any two of the three motor wires, and execute the start-up procedure, beginning at Step 10.

10.5 Potentiometer commands

Potentiometer P1 sets the rotor target mechanical frequency and thus the motor speed from the minimum (maximum CCW position) to the maximum speed (maximum CW position). The PI regulator gives the value of the voltage index to reach the target speed. This setting is always internally limited with a V/F curve (refer to User Manual UM0121).

Potentiometer P2 disabled by default or sets the integral coefficient of the microcontroller (when this feature is selected by the user).

Potentiometer P3 sets the Phase Shift (by default) or sets the proportional coefficient of the microcontroller (when this feature is selected by the user).

Note: For configuration of the software library with RDK-GUI, see User Manual UM0121.

Appendix A SEMITOP 3 Power Board characteristics

A.1 Front-end

The front-end section provides the supply voltage from the DC source via FST1 and FST2.

The jumper settings are:

- The DC source is preferred during development. When operating with low DC voltage (<30VDC), an external 15V auxiliary voltage must be supplied via connector CON2 and jumpers J14 and J8 must be removed.
- Place a jumper between pins 1 and 2 of Jumper J2.

A.2 Auxiliary supply

This Buck Converter uses a VIPer12A regulator that provides charging current for reliable start-up capability, an integrated PWM controller, and thermal as well as over-current protection.

The PWM controller is very simple and does not require an external feedback compensation network. The regulation circuit is decoupled from the supply circuit using a separate diode (D1) and capacitor (C2) to supply the zener diode (D3) on the FB pin. D1 is a low voltage diode (e.g. 1N4148) that allows the voltage on VDD to reach the start-up value. D2 and C2 are essentially used to detect peak output voltage.

To prevent disturbance resulting in possible output over-voltage or incorrect start-up, a zener diode (D6) is connected across the output circuit. For further details, refer to Application Notes AN1317 and AN1357.

An insulated axial inductor may be used to provide a voltage oscillation filter. This type of inductor meets low cost considerations but it produces a high series resistance that adversely affects the efficiency of the converter. The current capacity of this type of inductor is determined, for any given package, by its series resistance. For example, a 1.5mH inductor has a current capacity of about 100mA since its series resistance is about 30R.

The 5V is supplied from the 15V using an L78L05 three-terminal positive regulator. It provides internal current limiting and thermal shutdown. The 5V zener diode (D5) decreases the voltage regulator temperature for lifetime-sensitive applications.

Note: When the line voltage is lower than 30V, an external 15V auxiliary power supply is mandatory. It must be plugged into CON2, and J14 and J8 must be removed.

A.3 Power stage

The default value of the sense resistor R10 is 0.02Ω. It must be adjusted depending on actual operating conditions. The R_{SENSE} value, together with the resistors R38, R20, and R14 (mounted on the ControlBD-ST7FMC2 board), sets the maximum limit threshold for the motor current above which a hardware overcurrent protection event is validated. In this condition, the red LED starts to blink and the controller passes into the Reset state, where the motor does not run anymore. To rearm the controller, the AC (or DC) power supply must be turned off and it is necessary to wait for the bulk capacitors to discharge completely.

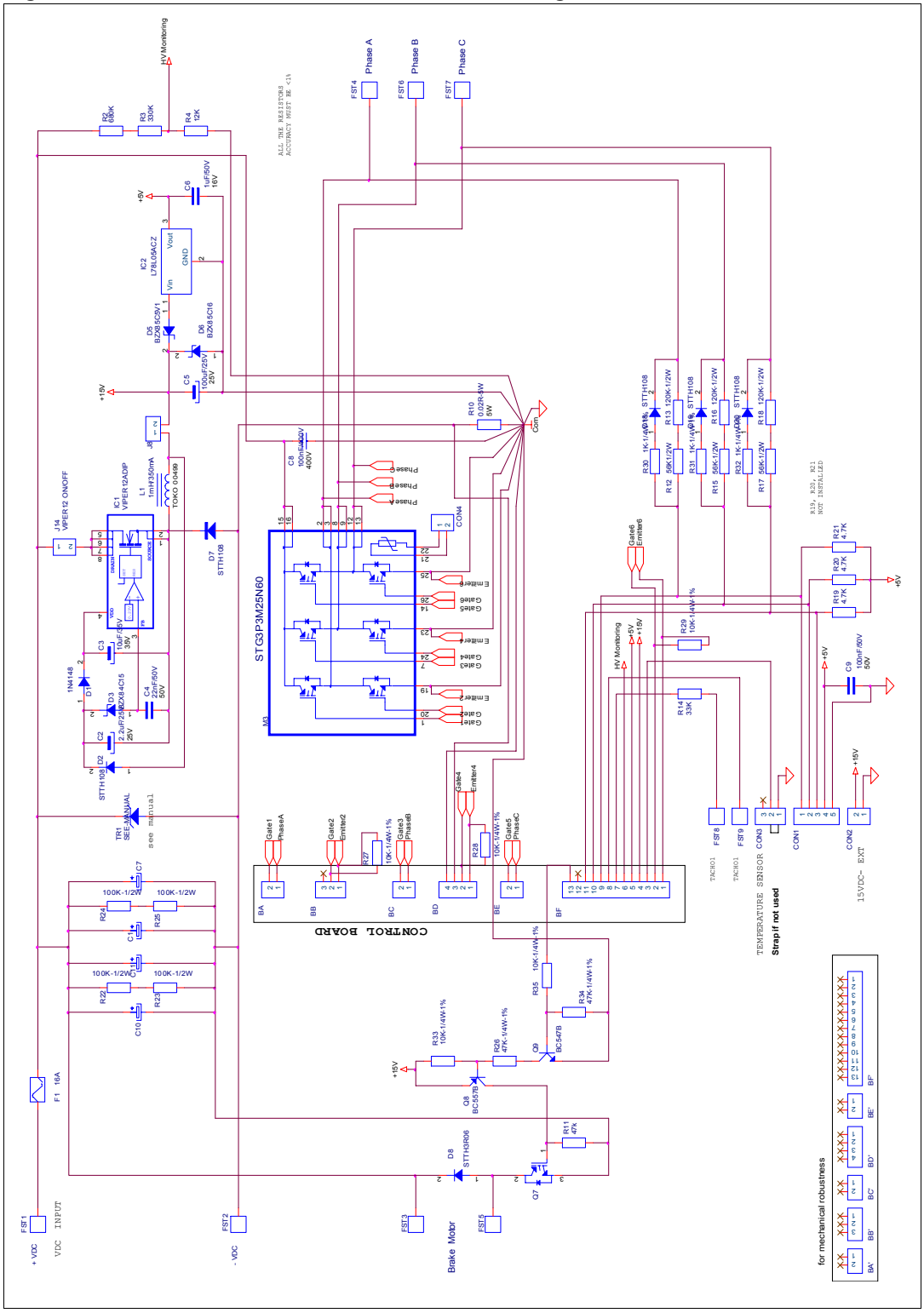
The maximum limit for the motor current is fixed at 34A (peak value).

Note: If the board is going to drive a sensorless BL(PM)DC motor, six phase voltage sense resistors must be present.

If the Power Board is linked to three Hall Effect sensors via connector CON1, resistors R19, R20, R21, and capacitors C22, C23, and C24 (1nF) in the ControlBD-7FMC2 must be assembled while removing resistors R7, R10, and R12.

Appendix B SEMITOP 3 Power Board schematic diagram

Figure 3. SEMITOP 3 Power Board schematic diagram



Appendix C Bill of material

Table 3. Bill of material

Index	Qty	Reference	Value / Part Number	Package	Manufacturer	Manufacturer's ordering code / Orderable Part Number	Supplier	Supplier's ordering code
1	2	BA' and BA	2x2SIP100	FEMALE		5-7716	ELCART	
2	2	BB' and BB	2x3SIP100	FEMALE		5-7716	ELCART	
3	2	BC' and BC	2x2SIP100	FEMALE		5-7716	ELCART	
4	2	BD' and BD	2x4SIP100	FEMALE		5-7716	ELCART	
5	2	BE' and BE	2x2SIP100	FEMALE		5-7716	ELCART	
6	2	BF' and BF	2x13SIP100	FEMALE		5-7716	ELCART	
7	1	CON1	CON1	5SIP100-TRH		531-936	R.S.	
8	2	CON2 and J8	CON2	2SIP100-TRH		531-936	R.S.	
9	1	CON4	CON4	4SIP100-TRH		531-936	R.S.	
10	4	C1, C7, C10 and C11	SEE-MANUAL	electolytic-TRH				
11	1	C2	2.2uF/25V	electolytic-TRH				
12	1	C3	10uF/35V	electolytic-TRH				
13	1	C4	22nF/50V	CK05-Ceramic				
14	1	C5	100uF/25V	electolytic				
15	1	C6	1uF/50V	CK06-Ceramic				
16	1	C8	100nF/400V	Polyester				
17	1	C9	100nF/50V	CK05-Ceramic				
18	1	D1	1N4148	DO39-TRH				
19	5	D2, D7, D18, D19 and D20	STTH108	DO41-TRH	ST	STTH108	ST	
20	1	D3	BZX84C15	DO41-TRH				
21	1	D5	BZX85C5V1	DO41-TRH				
22	1	D6	BZX85C16	DO41-TRH				
23	1	D8	STTH3R06		ST	STTH3R06	ST	

Table 3. Bill of material (continued)

Index	Qty	Reference	Value / Part Number	Package	Manufacturer	Manufacturer's ordering code / Orderable Part Number	Supplier	Supplier's ordering code
24	1	FST1	VDC+	Pcb-Spade-Terminals		534-834	R.S.	
25	1	FST2	VDC-	Pcb-Spade-Terminals		534-834	R.S.	
26	1	FST3	Brake Motor	Pcb-Spade-Terminals		534-834	R.S.	
27	1	FST4	Phase A	Pcb-Spade-Terminals		534-834	R.S.	
28	1	FST5	Brake Motor	Pcb-Spade-Terminals		534-834	R.S.	
29	1	FST6	Phase B	Pcb-Spade-Terminals		534-834	R.S.	
30	1	FST7	Phase C	Pcb-Spade-Terminals		534-834	R.S.	
31	1	FST8	TACHO1	Pcb-Spade-Terminals		534-834	R.S.	
32	1	FST9	TACHO2	Pcb-Spade-Terminals		534-834	R.S.	
33	1	F1	16A	6.3X32		247-3983	R.S.	
34	1	IC1	VIPER12ADIP		ST	VIPER12ADIP		
35	1	IC2	L78L05ACZ		ST	L78L05ACZ		
36	1	CON3	CON3	3SIP100		531-936	R.S.	
37	1	J14	2SIP100	STRIP-LINE		531-936	R.S.	
38	1	L1	1mH/350mA		TOKO	03149	R.S.	228-545
39	1	M3	STG3P3M25N60		ST	STG3P3M25N60	ST	
40	1	Q7	STGP7NC60HD		ST	STGP7NC60HD	ST	
41	1	Q8	BC557B	TO92				
42	1	Q9	BC547B	TO92				
43	1	R2	680K-1/4W-1%					
44	1	R3	330K-1/4W-1%					
45	1	R4	12K-1/4W-1%					
46	1	R10	0.02R-5W	Low Inductive	IRC	LOB5	Distrelec	71-05-28
47	1	R11	47k-1/4W-1%					
48	1	R12	56K1/2W					

Table 3. Bill of material (continued)

Index	Qty	Reference	Value / Part Number	Package	Manufacturer	Manufacturer's ordering code / Orderable Part Number	Supplier	Supplier's ordering code
49	3	R13, R16 and R18	120K-1/2W					
50	1	R14	33K-1/4W-1%					
51	2	R15 and R17	56K-1/2W					
52	3	R19, R20 and R21	4.7K-1/4W-1%	Not Mounted	Not Mounted	Not Mounted	Not Mounted	Not Mounted
53	4	R22, R23, R24 and R25	100K-1/2W					
54	2	R26 and R34	47K-1/4W-1%					
55	5	R27, R28, R29, R33 and R35	10K-1/4W-1%					
56	3	R30,R31,R32	1K-1/4W-1%					
57	2	F1-Pcb-Fuse-Holder				410-7874	R.S.	
58	1	TR1	Transil	See manual	ST		ST	
34A	1	Socket DIL 8 x Viper 12A						

Revision history

Table 4. Document revision history

Date	Revision	Changes
30-Jun-2006	1	Initial release.
25-Jul-2006	2	Updated *A.1: Front-end on page 23*.

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